# Encapsulated Chip and Procedure for its Manufacture

## FIELD OF THE INVENTION

**[0001]** The invention generally relates to an encapsulated chip and specifically to an encapsulated transponder chip in a smart label.

## BACKGROUND OF THE INVENTION

**[0002]** The cost of producing integrated circuits has fallen considerably in the past few years. As a consequence, a considerable range of new application fields has opened up for integrated circuits. Examples of this are the so-called smart labels for marking goods and for the identification of goods. Smart labels consist of a transponder chip in which the product-relevant information is stored, and an aerial to couple it to a reading device, which enables non-contact reading of the data stored in the transponder chip.

**[0003]** In the case of many smart labels, the transponder chip is built onto a base substrate that surrounds the aerial in the form of a conductive layer. The aerial is connected to the transponder chip. For these applications, the chips may be packed into a housing of, for example, plastic, or they may be directly built onto the base substrate, for example by means of flip-chip technology.

## SUMMARY OF THE INVENTION

**[0004]** The invention provides a new type of encapsulated chip, particularly suitable for smart label applications, which has a housing that may be of flexible construction and which, at the same time, facilitates external contacting of the chip, and

which can be produced by a simple and cost-effective process, whereby the chip is exposed to very little mechanical stress during the production process of the housing.

**[0005]** According to an embodiment of the invention, the chip is built onto a baseplate, on which the chip is located in such a way that its contact surfaces face away from the baseplate, where a layer of conductive material arranged around the chip is applied to the baseplate, which serves to connect the chip, is at least exactly as high as the chip, and functions as support for a cover plate arranged on the layer, one side of which, opposed to the chip, being provided with conductive surfaces that are arranged in such a way as to form a connection between the chip and the layer.

**[0006]** The chip according to and embodiment of the invention is of particularly simple construction that makes possible a cost-effective production process, consisting of only a few process steps, which is of particular importance when mass products, such as smart labels, are to be manufactured. The cover plate fulfils a dual function in this case. It allows the encapsulation of the chip and, at the same time, the establishment of electrical contact between the chip and the conductive layer that may consist, for example, of a transponder aerial. The chip is also mechanically stress-relieved in that the conductive layer is at least as high as the chip, or higher than the chip. This fact is particularly useful when the chip is integrated in a smart label.

**[0007]** The requirement of the invention is met, according to the invention, by several processes for the manufacture of encapsulated chips.

**[0008]** According to a first method for the manufacture of an encapsulated chip according to the invention, the chip is attached to a baseplate in such a way that its contact surfaces face away from the baseplate, and a conductive layer, that serves to connect the chip and that is at least as high as the chip, is applied around the chip onto the baseplate. Furthermore, a cover plate is provided where on one of its sides one or more conductive surfaces are arranged in such a way that they can form a connection between the chip and the layer. An anisotropically conductive film is then applied to one side of

the cover plate and the cover plate is then aligned over the baseplate so that the side with the conductive surface or the conductive surfaces, respectively, is arranged over the chip so as to enable a connection between the chip and the layer to be formed. The cover plate is finally pressed onto the layer, under application of heat, in such a way that the anisotropically conductive film forms a mechanical and an electrical connection between the contact surfaces of the chip and the conductive surface or the conductive surfaces, respectively, of the cover plate and, at the same time, an electrical and a mechanical connection between the conductive surface or the conductive surfaces, respectively, of the cover plate and the layer.

**[0009]** According to a second method for the manufacture of an encapsulated chip according to the invention, a conductive layer which serves to connect the chip and that is at least as high as the chip itself, is applied to a baseplate around an area intended for the chip. Then one or more conductive surfaces are arranged on one side of a cover plate in such a way that they can form a connection between the chip and the layer, and an anisotropically conductive film is applied over the conductive film on one side of the cover plate. The chip is then positioned on the anisotropically conductive film so that its contact surfaces point towards the cover plate, and the cover plate is positioned on the baseplate in such a way that the chip comes to rest on the surface area intended for it and a connection between the chip and the layer can be formed. The cover plate is finally pressed onto the layer, under application of heat, in such a way that the anisotropically conductive film forms a mechanical and an electrical connection between the contact surfaces of the chip and the conductive surface or the conductive surfaces, respectively, of the cover plate and, at the same time, an electrical and a mechanical connection between the conductive surface or the conductive surfaces, respectively, of the cover plate and the layer.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** Advantageous further developments of the invention are characterized in the sub-claims.

**[0011]** The invention shall now be explained in exemplified form with reference to the drawing, where

Fig. 1 represents a sectional side view of a first embodiment version of an encapsulated chip according to the invention,

Fig. 2 a plan view of a further embodiment version of a chip according to the invention,

Figs. 3a to 3g sectional side views of the parts of an encapsulated chip produced during the individual manufacturing stages in a first procedure according to the invention for the production of an encapsulated chip, and

Figs. 4a to 4g sectional side views of the parts of an encapsulated chip produced during the individual manufacturing stages in a second procedure according to the invention for the production of an encapsulated chip.

## DETAILED DESCRIPTION OF THE PRESENT INVENTION

**[0012]** Figure 1 shows an encapsulated chip according an embodiment of the invention. The chip 10 is attached to a baseplate 12 with its inactive back side. The baseplate 12 may consist of a rigid base material, for example an epoxy resin with glass fiber reinforcement, or it can be a flexible foil of, for example, polyethylene (PET) or polyamide. In order to achieve a flexible construction, the inactive back side of the chip

10 can be ground down to the extent that it becomes flexible. With a chip 10 consisting mostly of silicon, this flexibility can be achieved at a thickness of less than 50 μm.

**[0013]** An electrically conductive layer 14 that can consist of, for example, aluminum or copper, is applied to the baseplate 12. This layer 14 serves to connect the chip 10 to other component parts arranged on the baseplate 12, which are not represented in the figure 1. The electrically conductive layer 14 is applied around the chip 10, and is so high that it is at least as high or higher than the chip 10 together with its contact surfaces 20. If the chip 10 is made flexible by grinding it down, the layer 14 will be approximately 50 μm high. The layer 14 can consist, for example, of two narrow aluminum strips, which are arranged along two sides of a rectangular chip 10. It is not absolutely necessary for the layer 14 to surround the chip 10 completely. It is only important for the conductive layer 14 to be able to serve as a support for a cover plate 16. Conductive surfaces 18 are fitted to the cover plate 16, which, for example, can also consist of a flexible foil, and which provide an electrical contact between the conductive layer 14 on the baseplate 12 and the contact surfaces 20 of the chip 10. The conductive surfaces 18 can, for example, consist of glued-on thin aluminum or copper strips, or be printed on in the form of an electrically conductive lacquer (such as graphite lacquer).

**[0014]** The chip 10 is surrounded by filling material 26. This may consist, for example, of two different glues: A conductive glue that is applied to the contact surfaces 20 and which connects the conductive surfaces 18 of the cover plate 16 with the contact surfaces 20 of the chip 10, as well as a non-conductive glue that surrounds the chip 10. In order to establish an electrical connection between the contact surfaces 20 of the chip and the conductive surfaces 18 of the cover plate 16, an anisotropically conductive film (ACF) can also be used, that is a material that has a very low electrical resistance in only one direction whilst it is virtually non-conductive in the direction perpendicular to the other. The anisotropically conductive film 26 may consist, for example, of an epoxy resin containing a very large number of electrically conductive particles, which are arranged so as to touch each other only along the direction in which electrical conductivity is desired.

The epoxy resin also serves as the filling material that fully encloses the chip 10 and protects it from external influences, such as touch contact or humidity.

**[0015]** The conductive layer 14 on the baseplate 12 can be contact-bonded to the conductive surfaces 18 of the cover plate 16 by purely mechanical means, such as by crimping. The electrical connection can also be achieved by means of an electrically conductive glue or an anisotropically conductive film.

**[0016]** Figure 2 shows the plan view of an embodiment version of the encapsulated chip according to the invention, where the conductive layer 14 on the baseplate 12 forms an aerial that is connected to a flexible transponder chip 30. The baseplate 12 may consist, for example, of a thin flexible PET foil, to which the aerial 14 of either copper or aluminum is attached. Conductive surfaces 18, of copper or aluminum, are arranged on the cover plate 16, which also consists of a thin flexible PET foil. An anisotropically conductive film 26 ensures the connection between the conductive layer 14 on the baseplate 12 and the contact surfaces 20 of the transponder chip 30.

**[0017]** The transponder chip 30, together with the aerial and the casing, can be embodied as a so-called smart label, where, for example, in the memory of the transponder chip 30, information is stored that represents the characteristics of an object to which the smart label is attached. Several of these smart labels may, for example, be attached to a paper strip, which then may be coiled up for compact transport and easy handling of the smart labels. In the case of these coiled rolls, which may contain thousands of coiled-up smart labels, enormous pressure is exerted on some of the individual smart labels and, in consequence, on the delicate transponder chips 30. The transponder chips 30 are well able to resist this pressure, since they are pressure-relieved by the conductive surfaces 14 that are as high or higher than the transponder chips 30, and occupy a relatively large surface area as compared with the transponder chip.

[0018] A procedure according to the invention for the manufacture of an encapsulated chip 10 shall be explained in the following, with reference to the figures 3a to 3g. In a first step, which is represented in figure 3a, a baseplate 12 is provided. The baseplate 12 may consist of a rigid base substrate, such as an epoxy resin with glass fiber reinforcement, or it may be embodied as a flexible foil consisting of PET or polyamide.

[0019] As can be appreciated in figure 3b, a conductive layer 14 is then applied to the baseplate 12. The conductive layer 14 may consist of, for example, copper or aluminum, and is at least as high as the chip 10 that will be added later (see figure 3c). The conductive layer 14 is applied to the baseplate 12 around an area intended to accommodate the chip 10.

[0020] As represented in figure 3c, the chip 10 is attached to the intended surface on the baseplate 12 by means of, for example, glue bonding. In a fourth step, as represented in figure 3d, a cover plate 16 is provided, which may be made of the same material as the baseplate 12. Two conductive surfaces 18, consisting for example of aluminum or copper, and separated from each other by an insulating section, are applied to this cover plate 16.

[0021] As can be appreciated in figure 3e, the cover plate 16 is provided in a next step with an anisotropically conductive film 26, which is applied onto the conductive surfaces 18.

[0022] Then, as may be appreciated in figure 3f, the side of the conductive surfaces 18 of the cover plate 16 is positioned over the baseplate 12 so that a first conductive surface 18 can make connection to both a first part of the conductive layer 14, as well as to a first contact surface 20, as can be appreciated on the left hand of figure 3f, and a second conductive surface 18, that is isolated from the first conductive surface 18, can make connection to both a second part of the conductive layer 14, as well as to a second contact surface 20.

[0023] In the last step, as shown in figure 3g, the cover plate 16 is pressed onto the baseplate 10 by means of a piston ram 32, and under the application of heat. The anisotropically conductive film 26 thereby establishes an electrical connection between the contact surfaces 20 of the chip 10 and the conductive surfaces 18 on the cover plate 16, as well as between the conductive layer 14 on the baseplate 12 and the conductive surfaces 18 on the cover plate 16. As a result of the application of both heat and pressure, the anisotropically conductive film 26 spreads around the chip 10 and seals this hermetically.

[0024] A second procedure according to the invention for the manufacture of an encapsulated chip is represented in the figures 4a to 4g. In a first step, represented in figure 4a, a baseplate 12 is provided. The baseplate 12 may consist of a rigid base substrate, such as an epoxy resin with glass fiber reinforcement, or it may be embodied as a flexible foil consisting of PET or polyamide.

[0025] In a second step (figure 4b) a conductive layer 14 is then applied to the baseplate 12. The conductive layer 14 may consist of, for example, copper or aluminum, and is applied to the baseplate 12 around an area intended to accommodate the chip 10 (see figure 4f). The conductive layer 14 is at least as high as the chip 10.

[0026] In the next step (figure 4c), a cover plate 16 is provided that may be made of the same material as the baseplate 12. Areal conductive layers, made of aluminum or copper for example, are applied to this cover plate 16. Two conductive surfaces 18 that are isolated from each other are represented in figure 4c.

[0027] As represented in figure 4d, the cover plate 16 is then provided with an anisotropically conductive film 26, which is applied to the side of the cover plate 16 with its conductive surfaces 18.

[0028] Following this, as shown in figure 4e, the chip 10 is applied to the cover plate 16 so that its contact surfaces 20 face the conductive surfaces 18, and an electrical

connection can be established in the desired way between some of the contact surfaces 20 of the chip 10 and specific conductive surfaces 18.

**[0029]** Then, as may be appreciated in figure 4f, the side of the cover plate 16 with the conductive surfaces 18 is positioned over the baseplate 12 so that parts of the conductive surfaces 18 can establish electrical connections to parts of the layer 14. The chip 10 is hereby positioned in a way that allows it to be surrounded by the conductive layer 14 on the baseplate 12.

**[0030]** In the last step, as shown in figure 4g, the cover plate 16 is pressed onto the baseplate 12 by means of a piston ram 32, and under the application of heat, as in the first step described above.

**[0031]** Procedures for the manufacture of an encapsulated chip 10, which may be modified in a plurality of ways, have been described by giving two concrete examples. The anisotropically conductive film 26 may be applied, for example, to only a smaller surface, whereby the conductive layer 14 and parts of the conductive surfaces 18 will not be covered. Then, before pressing the cover plate 16 onto the baseplate 12, the conductive layer 14 on the baseplate 12 and the conductive surfaces 18 on the cover plate 16 can be connected by crimping. The crimping connection can be achieved, for example, by a mechanical deformation process or by means of ultrasound. The connection can, of course, also be made by means of the anisotropically conductive film.